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In The Trenches

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Exploring the Critical Zone, Earth's Outer Skin

Our thoughts are with the people of Puerto Rico and the Virgin Islands following the natural disasters they endured recently. When Hurricane Maria made landfall in Puerto Rico on September 20, 2017, as a Category 4 storm with sustained winds of 155 mph, the eye passed just south of El Yunque National Forest, home to Luquillo CZO, featured in this article. On September 26, LCZO PI Bill McDowell reported that damage was severe, but they had accounted for almost everyone in their large extended "family." Most had no communications and gas was largely unavailable. They were starting to get into the field to resume minimal measurements of critical zone fluxes and ecology and to assess damage and where they might need help. Bill recommended that those wishing to help visit the donation site of Puerto Rico's First Lady Beatriz Roselló, Unidos por Puerto Rico: http://unidosporpuertorico.com/en/. — Don Duggan-Haas and Margaret Crowder

GETTING STUDENTS JAZZED ABOUT CRITICAL ZONE

Engaging Students in Authentic Inquiry Through Data Jam

Critical Zone (CZ) science provides a rich context for middle and high school students in Puerto Rico to investigate their own questions about a recent drought and historical storm events. The Critical Zone Observatories (CZOs) are part of a growing trend in environmental science to collect long-term data about environmental phenomena, which has led to a tremendous explosion of publicly available datasets on all facets of environmental science. This explosion of "Big Data" is rapidly transforming the nature of research in the environmental sciences (Soranno et. al., 2015). Yet our system of

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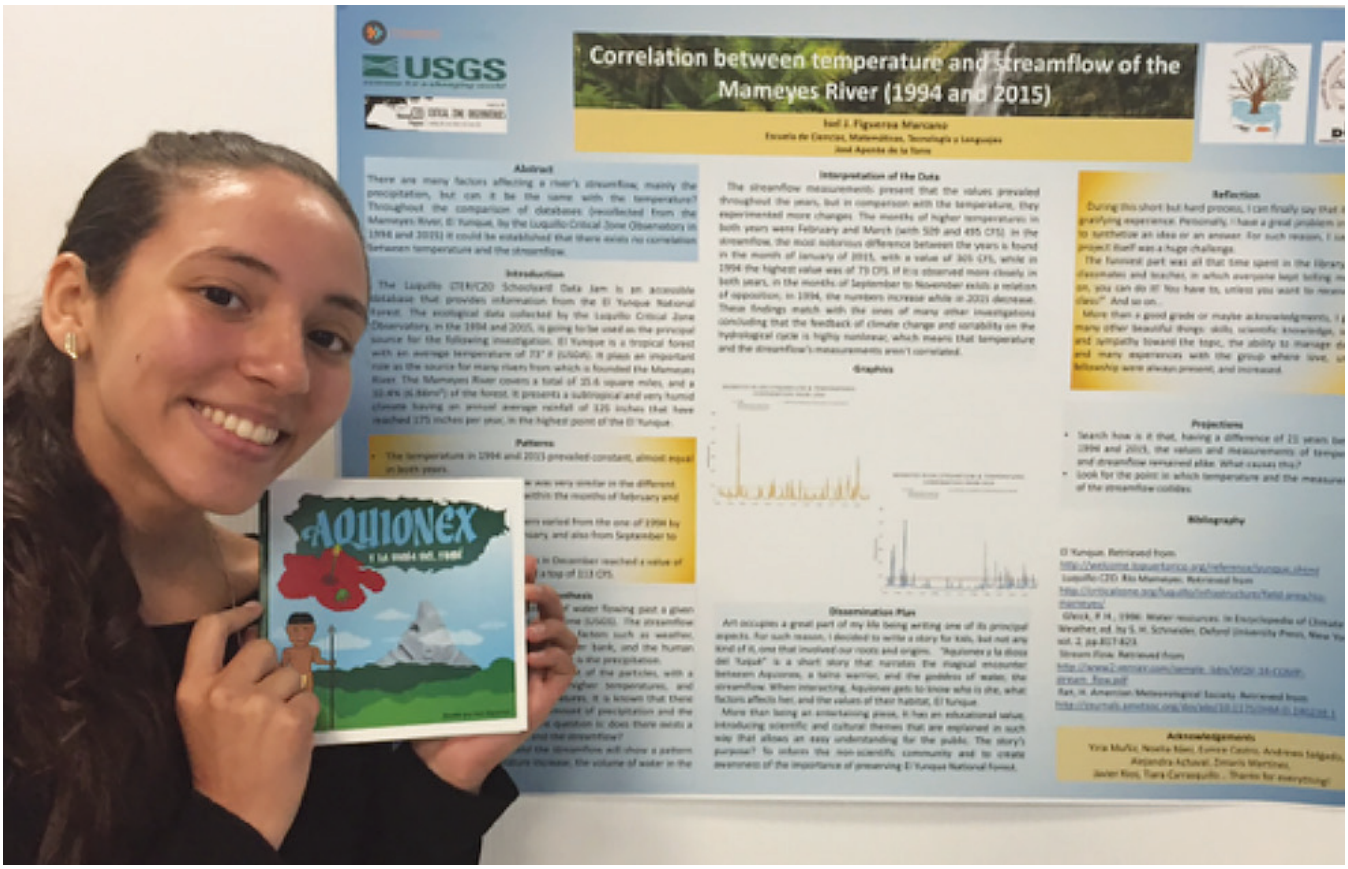

A student shows off her Data Jam children's book in front of her Data Jam poster. [Photo by Noelia Báez Rodríguez]

education is not keeping pace with these changes. To meet the demand for drawing inferences from Big Data, students need authentic experiences to investigate environmental science questions using big datasets (National Academies of Sciences, Engineering, & Medicine, 2016, p. 2). However, teachers find it challenging to support students in using data in authentic investigations, as statistical processes are largely ignored in schools (Makar & Rubin, 2014). It can also be challenging for teachers to find environmental datasets at a level of complexity appropriate for their students. At the same time, the Next Generation Science Standards (NGSS) highlight the need for data analysis in education to support students in becoming informed citizens, understanding and evaluating scientific arguments about environmental issues, and using scientific understanding to inform their decisions.

This article describes the second year of a pilot effort by the Luquillo Critical Zone Observatory (LCZO) and the Luquillo Long-Term Ecological Research Progam (Luq-LTER) to address these challenges by integrating LCZO, Luq-LTER, and US Geological Survey (USGS) datasets and a teaching strategy called Data Jam, which was developed at the Asombro Institute for Science Education. The essence of the Data Jam model is to support students in exploring, analyzing, and summarizing long-term data about the environment and then creatively communicating their discoveries to non-scientific audiences (Bestelmeyer et al., 2015). The Data Jam model also provides an opportunity for students to apply what they are learning in math about statistics and probability. The Common Core State Standards in Mathematics indicate that middle school students should learn to characterize a dataset in terms of center, spread, and shape (6.SP.A.2-3), compare two datasets and determine whether there is a difference in the center value (7.SP.B.3), and investigate patterns of association between two datasets using scatterplots and lines of best fit (8.SP.A.1-3).

The essence of the Data Jam model is to support students in exploring, analyzing and summarizing long-term data about the environment and creatively communicating their discoveries to non-scientific audiences.

To facilitate Data Jam implementation, we conducted a teacher workshop in fall 2016. Teachers then implemented the Data Jam with their students in the second semester and selected one of the resulting projects to submit for presentation at the annual Luq-LTER Schoolyard Symposium.

Data Jam Datasets

To address the challenge of finding appropriate datasets for students, we organized and provided datasets from LCZO, Luq-LTER, and USGS, which are available from the LCZO web site. We focused the datasets on two topics related to student experiences. Using local topics can enhance student motivation (see also Williams, Dykhoff, Pollak, & Brantley, 2017, this volume). One dataset revolved around drought. In 2015, Puerto Rico experienced one of the most severe droughts on record. Students and their families were subjected to water rationing throughout the summer as the island coped with reduced reservoir levels and low flows in the rivers that feed the island's water supply (AP, 2015). The drought dataset included data about rainfall, stream flow, and reservoir height for 2015, 1994 (another severe drought year), and 30-year averages. We also included soil moisture data collected by the LCZO for 2015. A second dataset revolved around tropical storm events, which students in Puerto Rico frequently experience. We included rainfall frequency, intensity, and event duration from storm events during the period 1992-2011.

Data Jam Workshop

In November 2016, twenty science teachers from Puerto Rican private and public schools participated in a six-hour Data Jam workshop, co-hosted with Forward Learning, an educational technology professional development provider in Puerto Rico. The workshop design incorporated the following best practices as suggested by Desimone and Garet (2015): it focused on important scientific content, built coherence through alignment to NGSS, and involved teachers as active participants. The workshop began with a general orientation about Data Jam, the available datasets, and the programs that generated the data.

Teachers present Data Jam projects to each other at the workshop. [Photo by Noelia Báez Rodríguez]

The teachers were also introduced to the graphing functionality of Microsoft Excel. After reviewing example Data Jam projects, teachers engaged in their own Data Jam. In the last phase of the workshop, teachers were provided an overview of best practices related to presentations using Microsoft PowerPoint and then applied those best practices by presenting their Data Jam projects to each other. Finally, the workshop ended with presentations from teachers who participated in the previous year's Data Jam (McGee & Rodriguez, 2016). These presentations focused on the teachers' experiences incorporating Data Jam into their classroom activities and the strategies they used to motivate students' involvement.

Data Jam Results

Eight teachers went on to implement the Data Jam model with their students during spring 2017, and subsequently submitted 10 projects for the symposium in May. At the symposium, students presented their Data Jam projects to a community of their peers from the participating schools as well as faculty and students from the University of Puerto Rico. All of the projects focused on the drought topic datasets. Most of the students asked questions that involved comparisons of one parameter between the 2015 and 1994 droughts. One project also added a comparison to the average. A handful of projects compared the relationship between different parameters in the same year. In all cases, the students graphed all relevant parameters over time and conducted a visual analysis of the graphs to draw conclusions about similarities and differences. None of the students applied what they should have learned in math class about making comparisons based on the characteristics of the dataset or creating scatterplots. One barrier to implementing the Common Core statistical strategies in Data Jam is that the recommended graphs can be unwieldy to produce in Excel. In our next Data Jam, we will explore the use of a free educational graphing tool, called CODAP, that provides explicit support for the kinds of representations that are recommended by the Common Core Math standards.

Along with the graphical representation of their results, students were also required to develop creative approaches to communicating their results. Sample creative products included a children's book about the relationship of the indigenous Taíno people of Puerto Rico with the Mameyes River (see picture on page 5); a skit based on *The Little Prince* that highlighted the impact of global warming on stream hydrology; and original drawings, songs, short stories, and poems describing the effects of drought on the Loíza Reservoir.

Conclusion

The second year of the Data Jam program showed that with a relevant research topic, rich CZO and LTER datasets, and high quality professional development, teachers can successfully engage students in authentic inquiry around important environmental research areas. However, there is room for improvement. As suggested by Desimone and Garet (2015), we hope to extend the duration of the professional development by incorporating additional teacher follow up

through periodic webinars. In addition, teachers need more support in how to help students apply their mathematical knowledge to summarize and analyze the data as evidence for their questions. We will also explore other topical datasets to expand the areas that might be of interest for students to pursue. With these continued improvements, the LCZO Data Jam model provides a robust approach for addressing the NGSS with critical zone science.

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ONLINE EXTRAS

This issue continues online with three additional articles, all of which focus on place-based and technology-rich exploration. Two of the articles also extend the CZ science theme. To access these articles, go to:

http://nagt.org/nagt/publications/trenches/index.html.

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